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09/341368

80 Rec'd PCT/PTO 08 JUL 1999

[67190/965158]

# REDUCTION OF SWITCH-ON TIME FOR ELECTRONICALLY CONTROLLED CONTACTORS

## ~~Background Information~~ Field of the Invention

The present invention relates to switchgear, in particular relays and/or contactors with a solenoid system that includes an armature and a yoke, a coil and an open- or closed-loop controller of the switchgear drive, wherein actual values of drive-specific switching parameters are measured by sensors.

## BACKGROUND INFORMATION

Switchgear having solenoid systems, for example, contactors, are used in drive and automation technology and serve, in conjunction with other components, for protecting and controlling electric loads.

In order to optimize such switchgear to their switching function, taking into consideration different operating conditions and specific equipment characteristics, the principle of controlled switching drives has been developed, which reduces the number of types of coils that were previously required due to their different excitation voltages. Such drives can be used for both AC and DC and, by reducing contact chatter, they reduce contact erosion and extend contact life. At the same time, the power consumption of the exciter circuit during the holding phase is reduced.

Thus, European Patent Application 376 493 ~~A1~~ describes a control circuit that allows for a high current during the closing operation of electromagnetic valves; this current is then reduced to a relatively low holding current after the closing operation. German Patent No. ~~Offenlegungsschrift~~ 30 47 488 A1 describes, in addition to a coil current controller, an induction controller having a Hall probe arranged in the yoke. These control principles provide a higher coil current for the closing operation, which is reduced after the closing

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operation to a value that just provides for the force required for holding the armature in the closed position. German Patent No ~~Offenlegungsschrift~~ 44 30 867 ~~A1~~ describes a switchgear drive control, which ensures that the optimum contact speeds and the limitation of the armature core impact speed are observed over the entire service life, taking into consideration interfering factors such as erosion and tolerances.

While efforts have been made to achieve the aforementioned object using the conventional ~~known~~ circuit arrangements for switchgear drives, either complex control algorithms have had to be used or concessions concerning the requirements of high closing speed of the contact with minimized chatter and low power consumption during the holding phase of the contactor have had to be made.

SUMMARY

An ~~The~~ object of the present invention is to provide a simple and sturdy control algorithm of the switchgear drive resulting in high contact closing speed and minimum chatter of these contacts and low power consumption of the exciter circuit during the holding phase of the contactor.

This object is achieved according to the present invention by the fact that, after a switching command, the control device does not affect an output quantity, for example, coil current I, until at least one predefined threshold value of the switching parameters, for example, contact speed ~~x~~ a1, is attained during a switching operation.

Thus it is achieved that the closing speed is very high, like in conventional contactor drives. After one or more limit values of specific switching parameters has been attained, such as time ~~t~~ or contact path ~~s according to Claim 2~~, the control device intervenes via flux ~~Φ~~ or coil current I ~~according to Claim 5~~ and thus minimizes chatter. In addition, power consumption by the exciter circuit during the holding phase of the contactor is thus reduced. These threshold values

can be transmitted to the control device via sensors. Lag elements in the control circuit also result in delayed response of the control device.

The invention is described in the following with reference to an embodiment.

Figure 1 shows a U core with fixed air gap, armature, coil and their control device.

Figure 2 shows a diagram where the magnetic flow $\Phi$ during the closing operation is plotted against time t for different control principles.

Figure 3 shows a diagram where the armature path s during the closing operation is plotted against time t for different control principles.

DETAILED DESCRIPTION

Figure 1 shows a yoke 1 designed as a U core 3 having a fixed air gap 2. A schematically illustrated coil 5, activated via a control device 6, is located on each leg 4 of yoke 1. A flux sensor 7, which transmits the instantaneous flux data to control device 6, is arranged in fixed air gap 2.

Figure 2 shows the variation of magnetic flux $\Phi$ in fixed air gap 2 of magnet yoke 1 over time t for different control principles. In the case of uncontrolled variation of magnetic flux $\Phi$, i.e., the entire control voltage U is always applied to coil 5, flux $\Phi$ has a variation A that is typical for the magnetic field, causing maximum acceleration of armature 8, which may then result in chatter on the fixed contact of the switchgear.

Curve C shows the variation of magnetic flux $\Phi$ when control device 6 intervenes immediately. Also in this case, the entire voltage U is applied to coil 5 up to time $t_1$. As soon as the predefined flux $\Phi_1$ is attained, coil current I is controlled so

that this value $\Phi_1$ of the flux is maintained virtually constant during the remaining time of the closing operation and during the holding phase of the contactor.

If control device 6 intervenes with a delay according to curve B, the entire control voltage U is again applied to coil 5, i.e., maximum acceleration initially occurs as in the case of unregulated contactor operation. After the elapse of a certain period of time $t_2$ after the switch-on command of the contactor $t_0$, control device 6 intervenes and, based on the value transmitted by flux sensor 7, reduces, by time $t_3$, coil current I and thus flux $\Phi$ to $\Phi_1$, which is sufficient for maintaining the contactor closed, while reducing chatter.

Figure 3 shows the variation of contact path s of a contactor over time t for different control principles, $s_o$ being the open switch position and $s_G$ being the closed switch position. In the case of unregulated contactor operation according to curve D, the contact closes fastest $t_{IV}$, since the full control voltage U is always applied to coil 5.

When the contactor drive is controlled immediately by control device 6 at time $t_{II}$ according to curve F, the longest switch-on times t occur, since, as in the case of curve C of Figure 2, the entire control voltage U is only applied for a short period of time $t_I$ to $t_{II}$.

According to curve E of Figure 3, the total switch-on time is reduced from $t_{VI}$ to $t_V$, i.e., by approximately 20% to 30% when control starts with a delay at time $t_{III}$.

As tests have shown, the relationships can be directly applied to solenoid systems whose yoke has an E-shaped design, for example.